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Passive sorting of invasive sea lamprey in the Great Lakes basin

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Advisory Committee:
Dr. Ulrich Reinhardt, Chair
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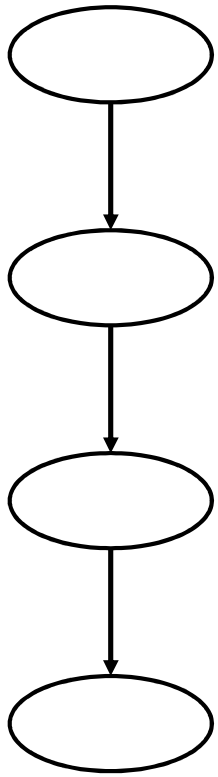
Today's Agenda

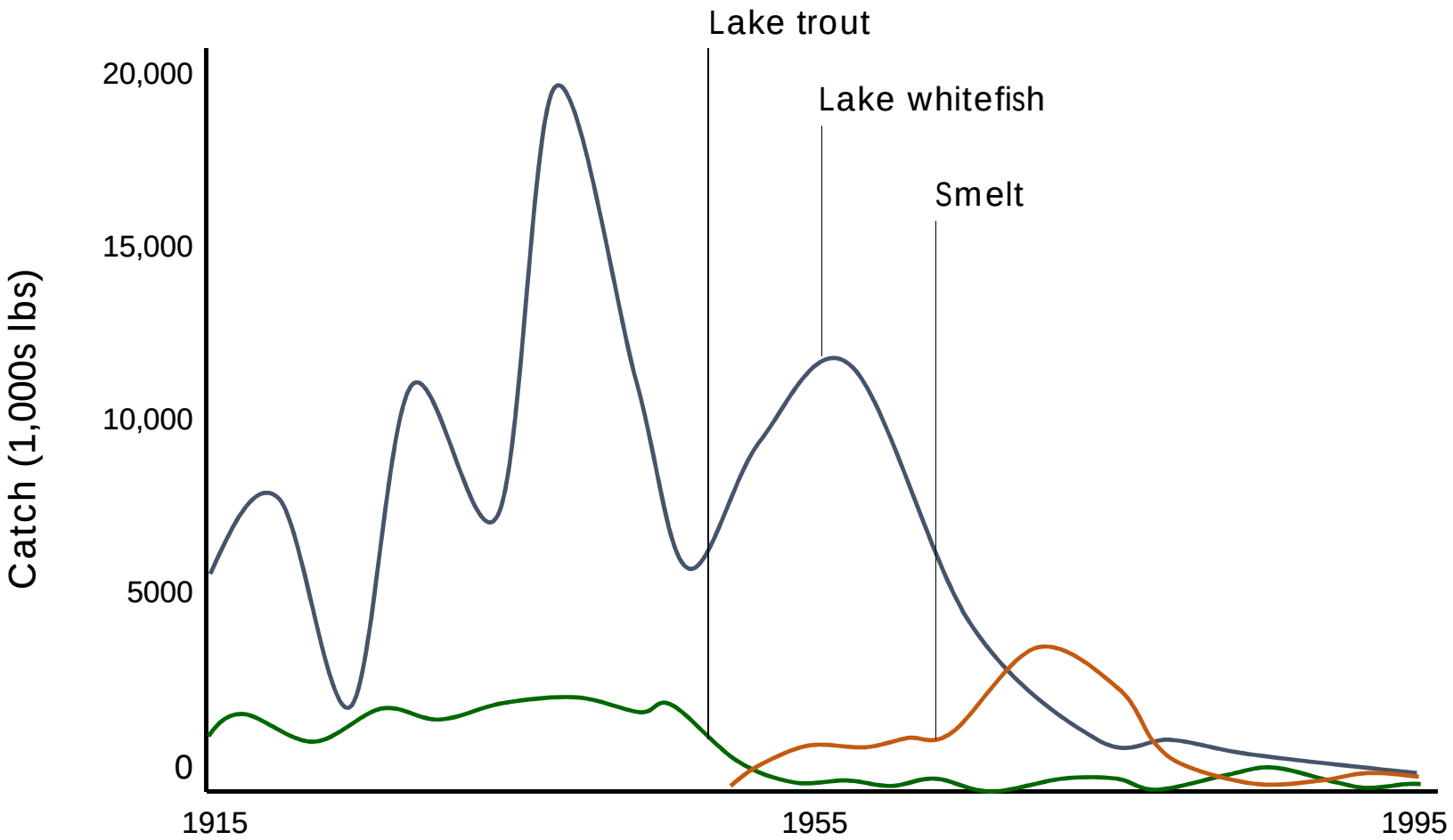
- Sea lamprey in the Great Lakes
- The use of barriers within the basin
- Selective passage as a solution to fragmentation
- Sorting methods
- Experimental design
- Results and conclusions



Sea lamprey are a severe ecological and economic pest

1. Sea lamprey are a costly and disruptive invasive species within the Laurentian Great Lakes basin.
   - Contributed to decline of keystone species such as lake trout.
   - Resulted in widespread trophic cascades.

Sea lamprey are a severe ecological and economic pest



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1. Sea lamprey are a costly and disruptive invasive species within the Laurentian Great Lakes basin.
   - Contributed to decline of keystone species such as lake trout.
   - Resulted in widespread trophic cascades.

2. Control tactics include in-stream barriers to prevent access to spawning habitat.
   - Delays and prevents spawning migration of native and desirable species.

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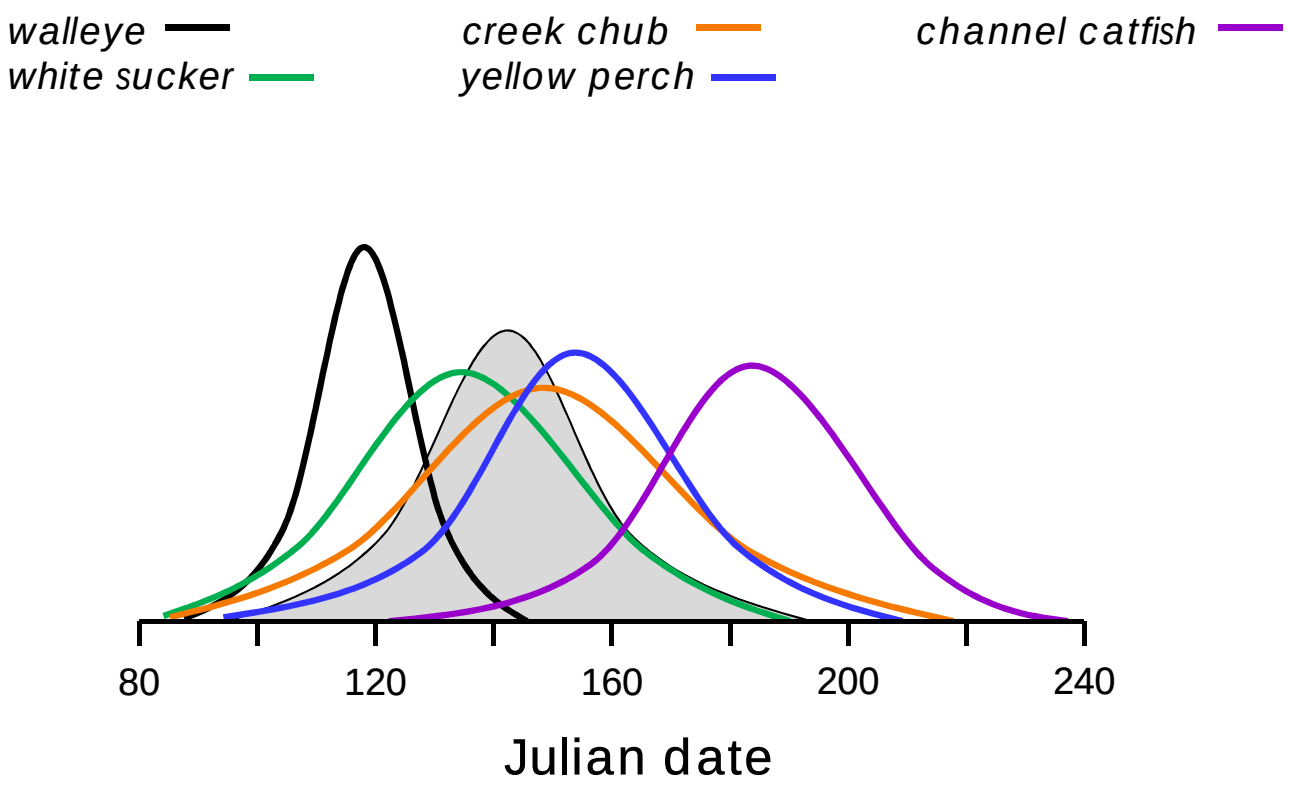
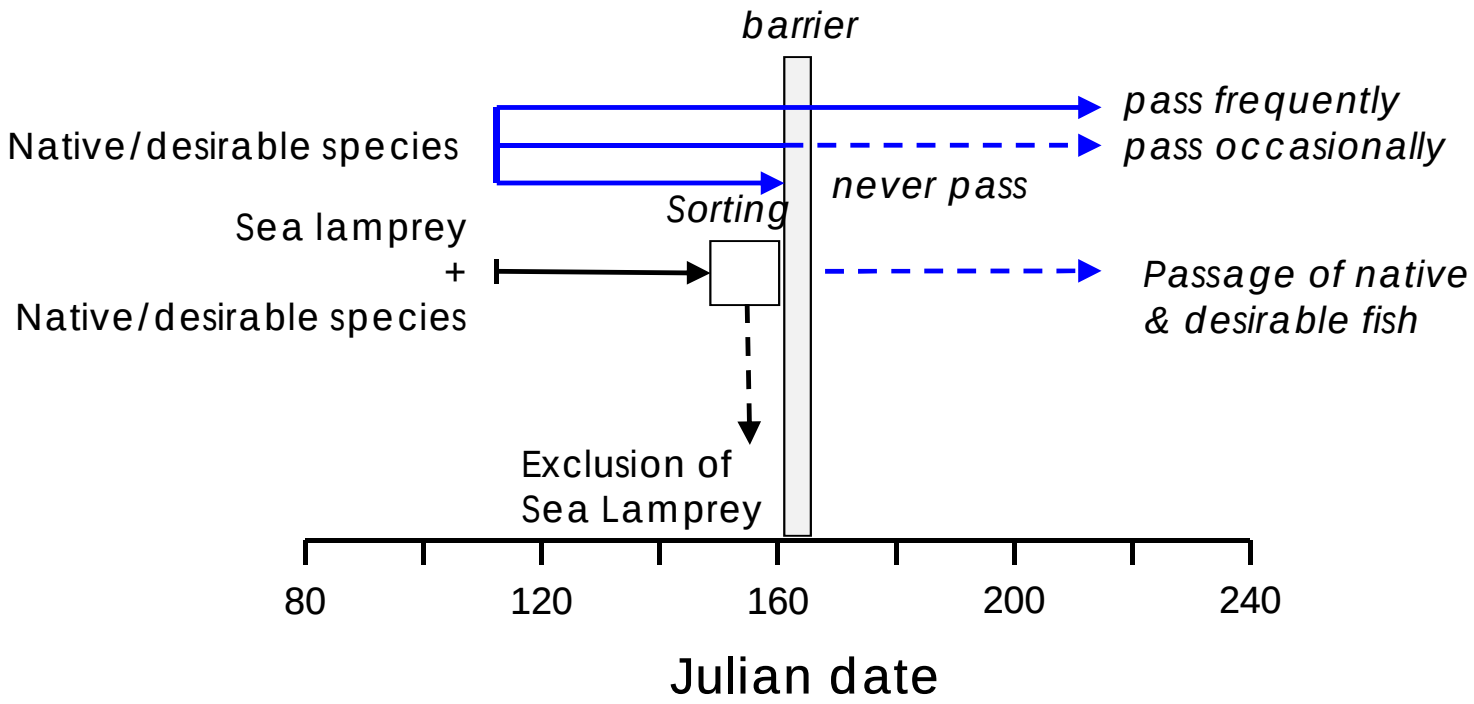


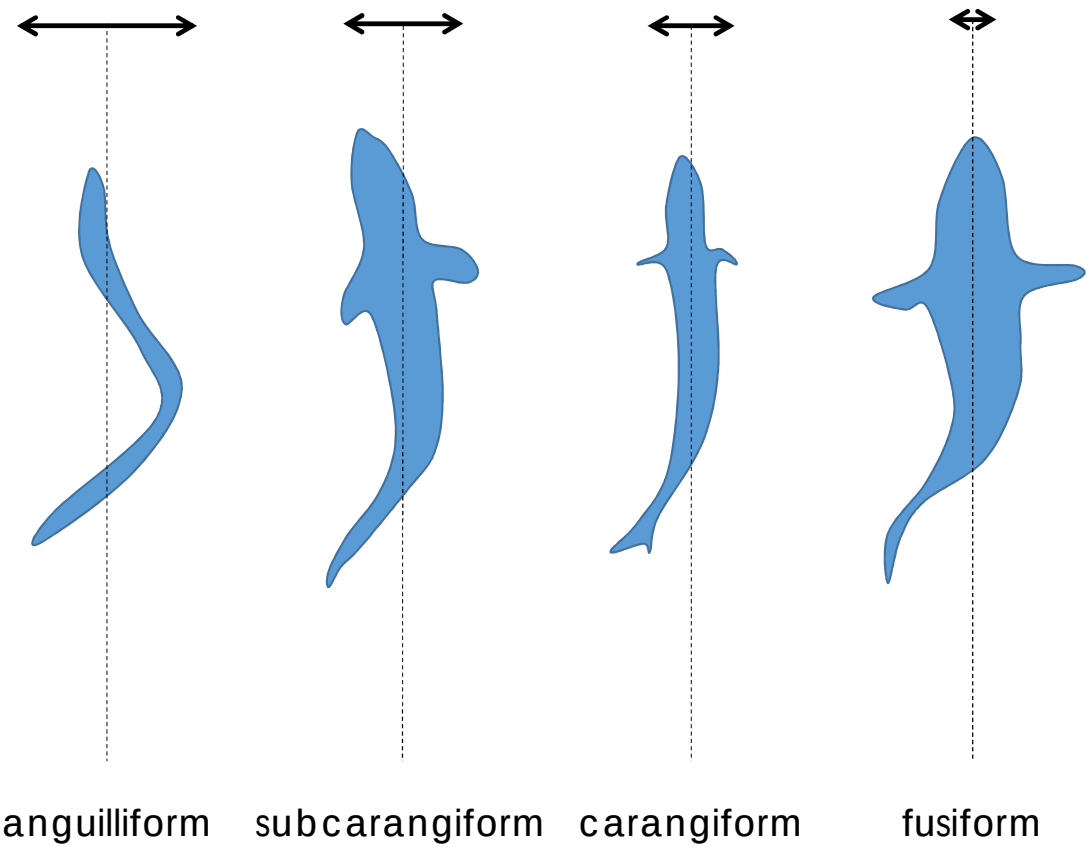
Adapted from Velez-Espino *et al*. (2011)

Sea lamprey are a severe ecological and economic pest



Adapted from Velez-Espino *et al*. (2011)

Anguilliform swimmers exhibit wide lateral displacement of head



Lampreys have a very different mode of locomotion compared to native/desirable species.

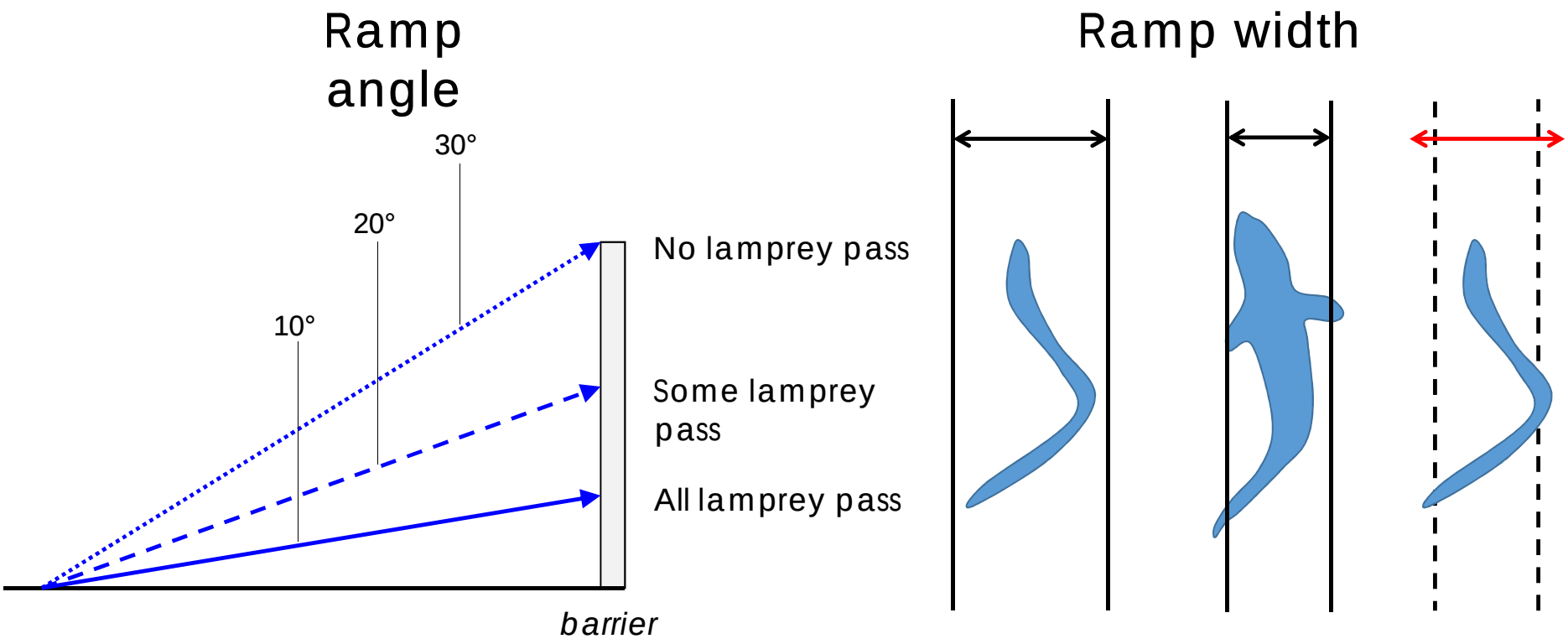
Most fishes in N. America are subcarangiform swimmers.

Anguilliform swimming is less efficient than carangiform/ subcarangiform

- 0.43 BL/beat vs 0.74 BL/beat

Redrawn from Fish Physiology (1978)

Differences in locomotion could allow for sorting of species



Ramp Angle Blocks Lamprey but With Low Native Passage

- Angles > 10 degrees block sea lamprey
- Low Native Passage
  - *0-13% passage for seven native species*
  - *Reduced water depth likely limited native success*

Adapted from Sherburne and Reinhardt 2016

Study objectives

Objective 1:
Investigate the effects of limiting the tail-beat amplitude of sea lamprey

Objective 2:
Revisit the efficacy of using ramp angle to sort sea lamprey

Objective 3:
Investigate the effects of discharge on fish performance

Experimental Setup

Variables Tested:

- Ramp width, Ramp angle, and Discharge
- 12 treatments total

Measures of performance:

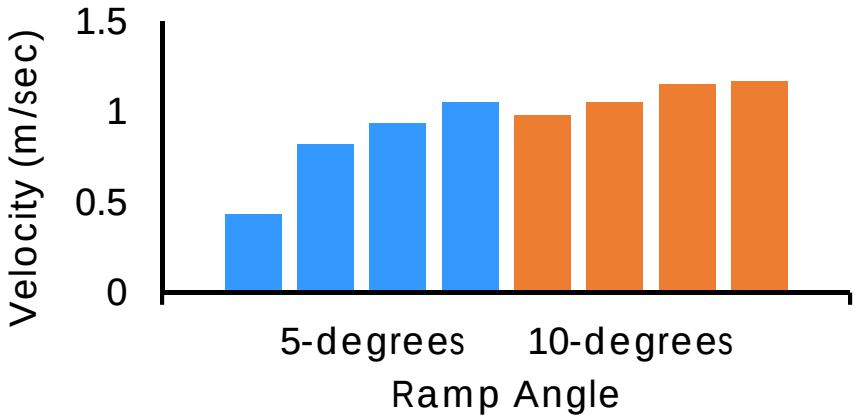
- Maximum height achieved
- Swimming speed
- Success rate

Fish behavior was recorded with Infrared cameras

Experimental Setup

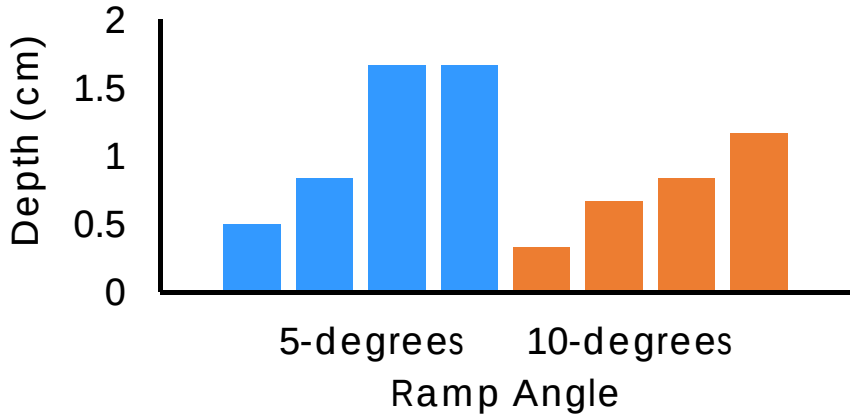
- April-June 2016:
  - Sea lamprey (TL 36.8-56.8 cm)
    - n=207
- September-November 2016:
  - Creek chubs (TL 92.0-24.9 cm)
    - n= 71
  - White suckers (TL 83.0-38.2 cm)
    - n= 60
- April-June 2017:
  - White suckers (TL 14.9-39.0 cm)
    - n = 33 (projected)

Channel Hydrology



Water Velocity (m/s):

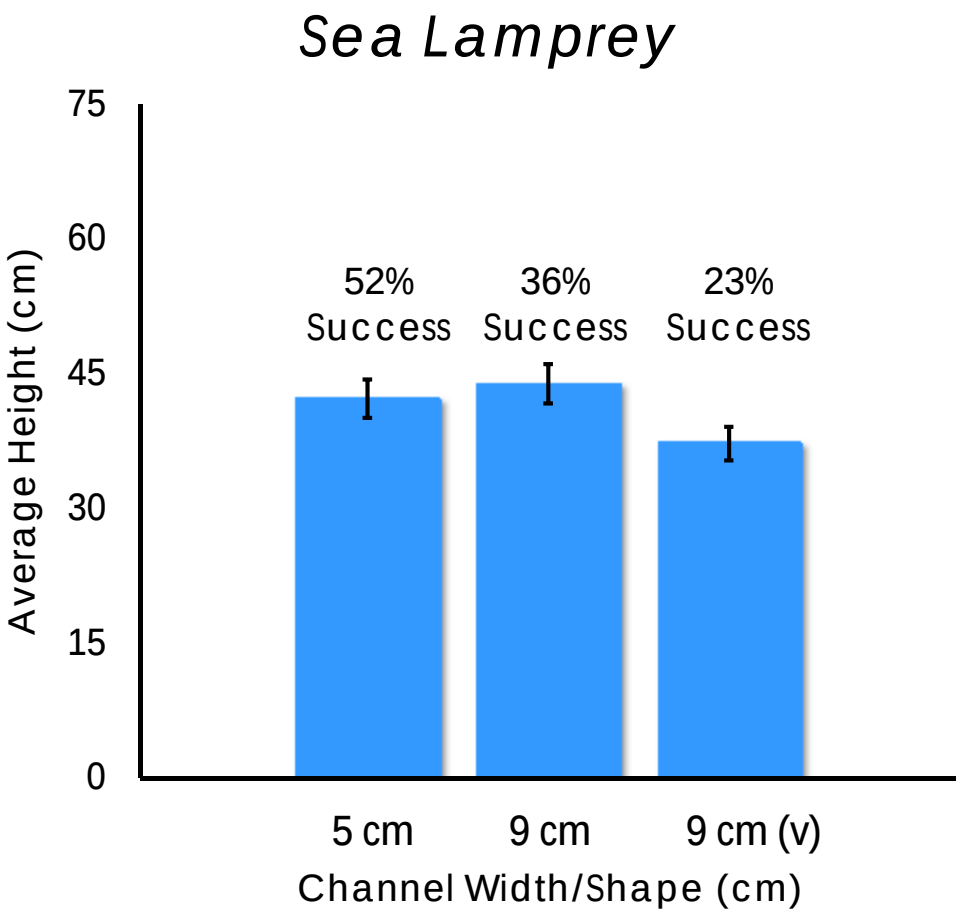
- 5-degrees: 0.5-1.05
- 10-degrees: 0.95-1.17

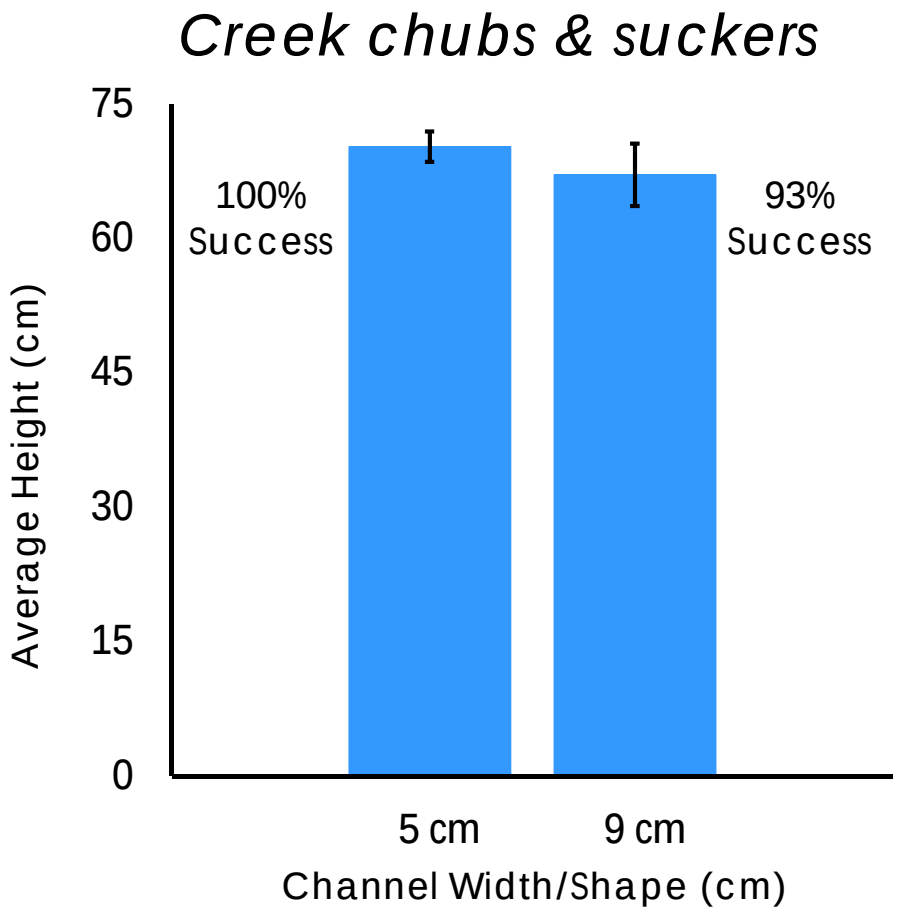


Water Depth (cm):

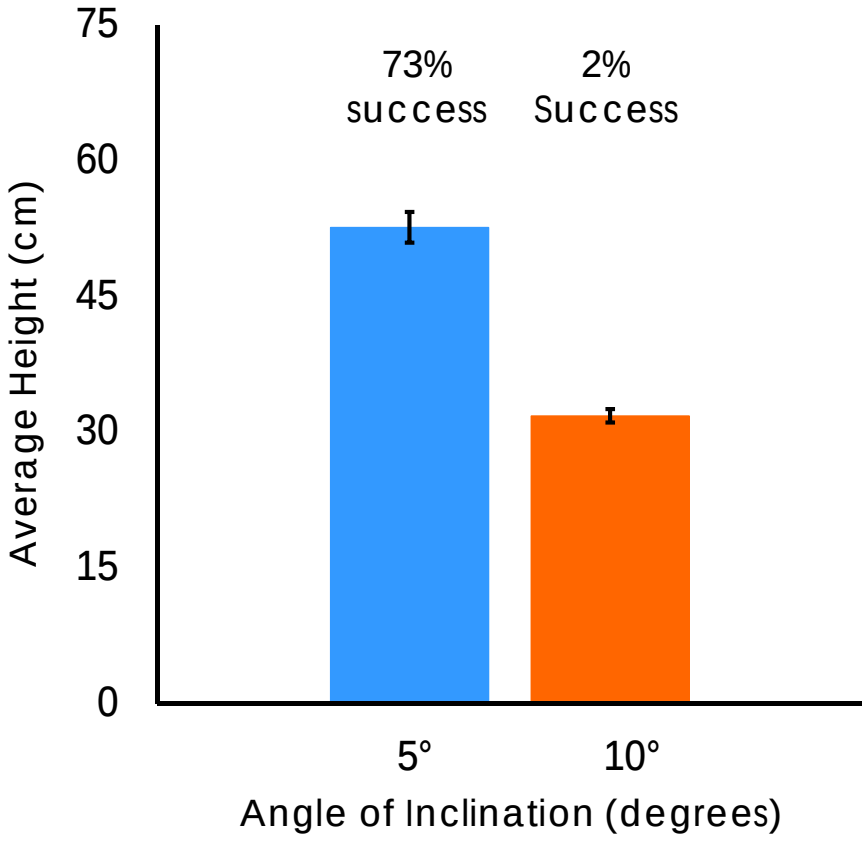
- 5-degrees: 0.5-1.6
- 10-degrees: 0.4-1.1

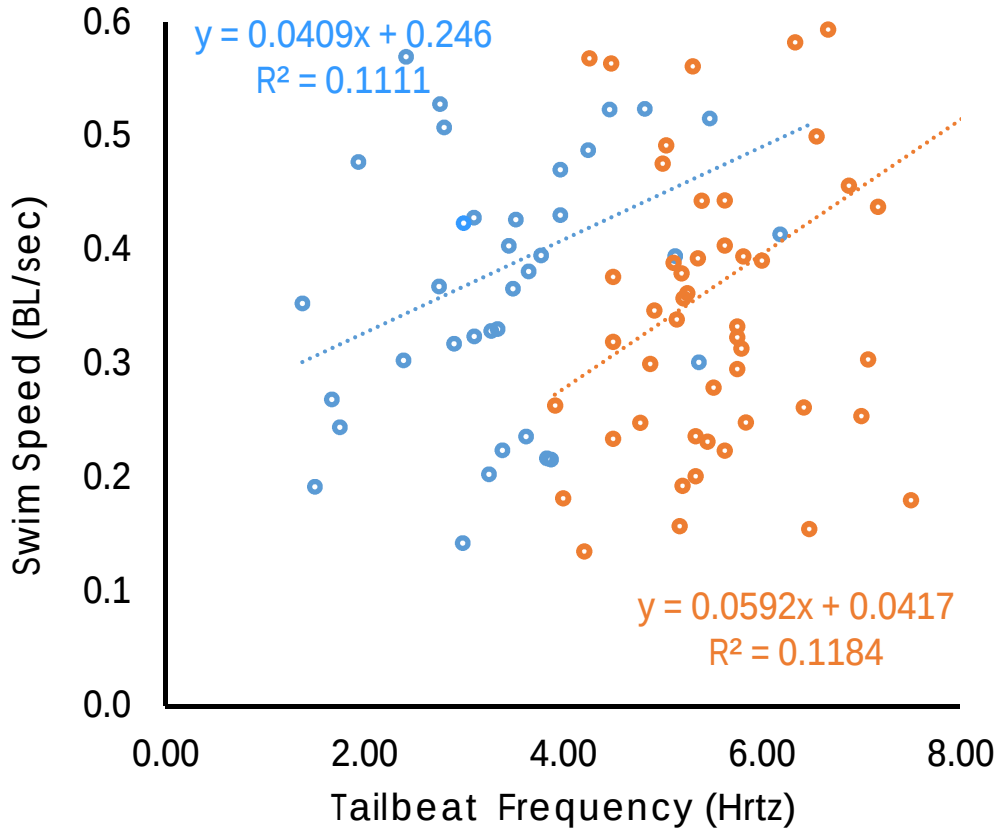
Ramp Width


Sea Lamprey
75
60
45
30
15
0
Average Height (cm)
52% Success
36% Success
23% Success
5 cm
9 cm
9 cm (v)
Channel Width/Shape (cm)

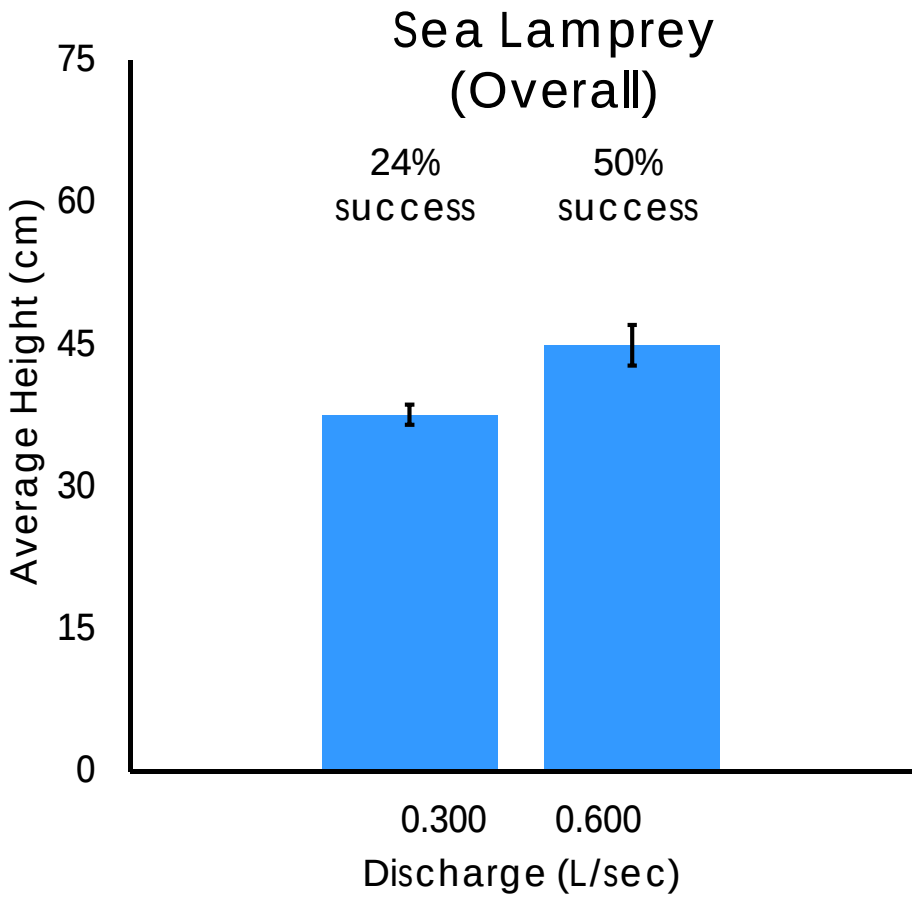

Creek chubs & suckers
75
60
45
30
15
0
Average Height (cm)
100% Success
93% Success
5 cm
9 cm
Channel Width/Shape (cm)

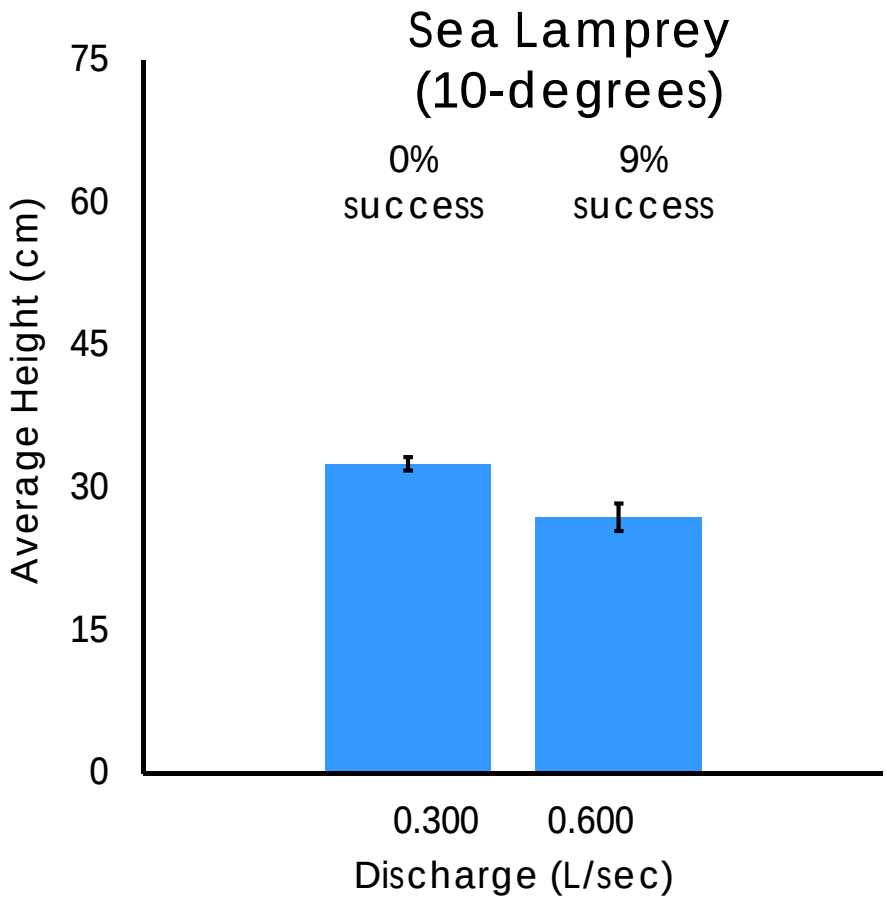
Ramp Angle


75
60
45
30
15
0
Average Height (cm)
73%
success
2%
Success
5°
10°
Angle of Inclination (degrees)

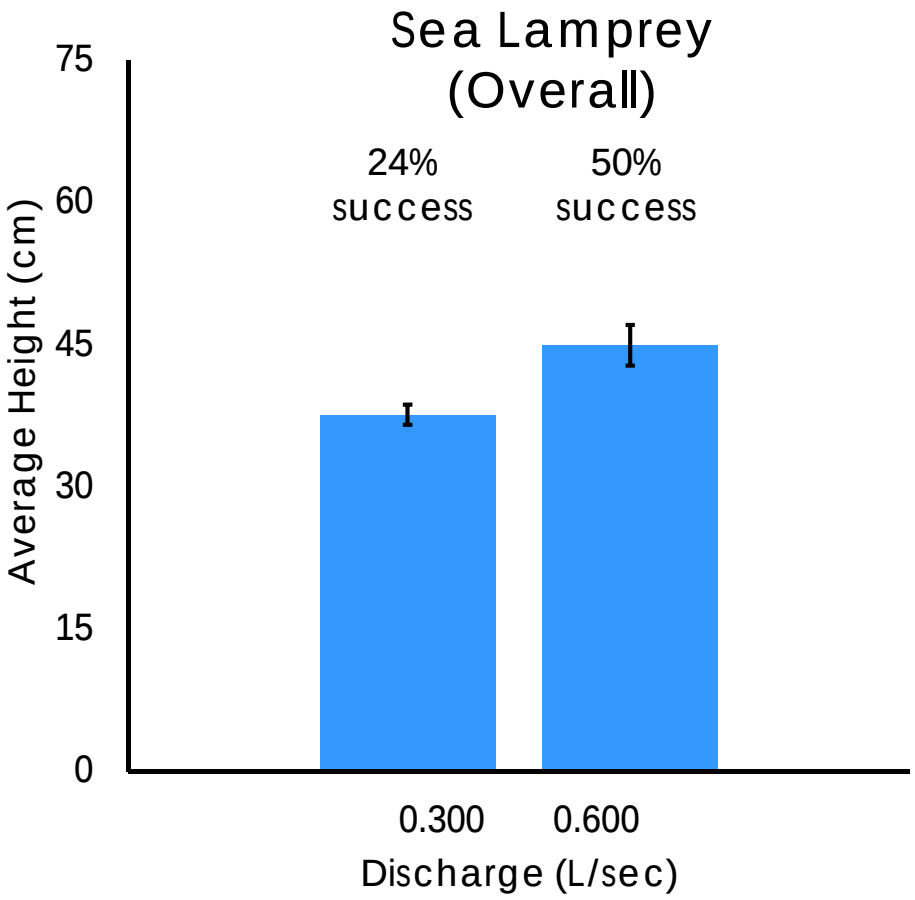

y = 0.0409x + 0.246
R² = 0.1111
y = 0.0592x + 0.0417
R² = 0.1184
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Swim Speed (BL/sec)
0.00
2.00
4.00
6.00
8.00
Tailbeat Frequency (Hrtz)

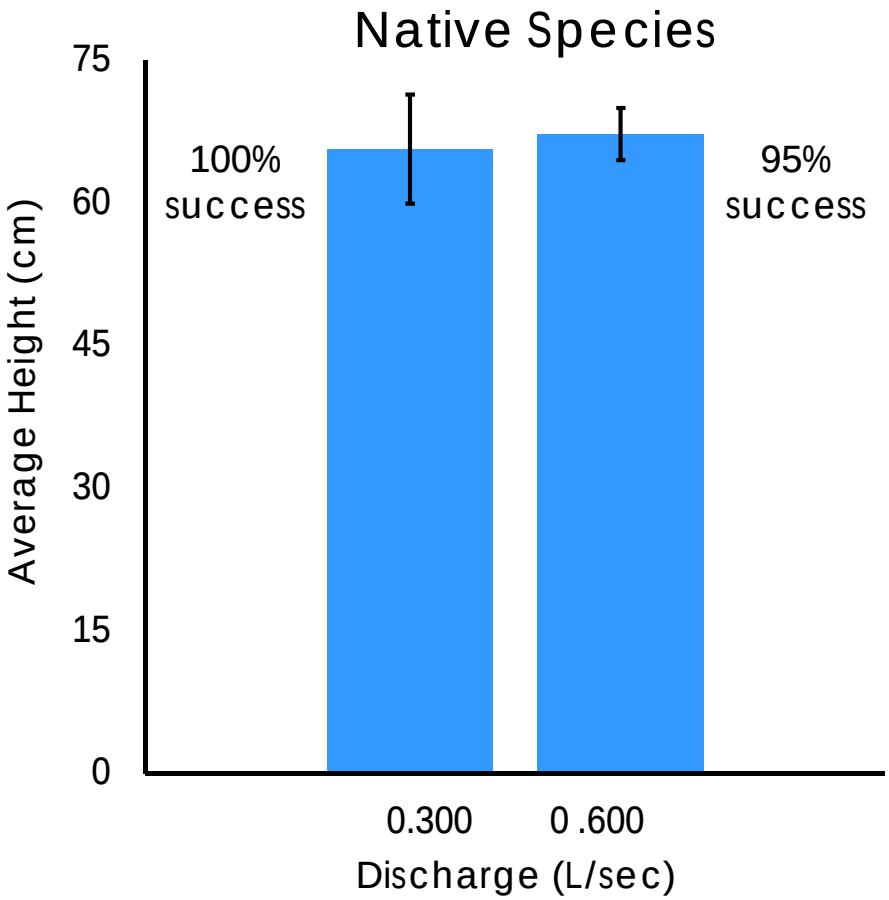
Discharge


Sea Lamprey
(Overall)
24%
success
50%
success
75
60
45
30
15
0
Average Height (cm)
0.300
0.600
Discharge (L/sec)

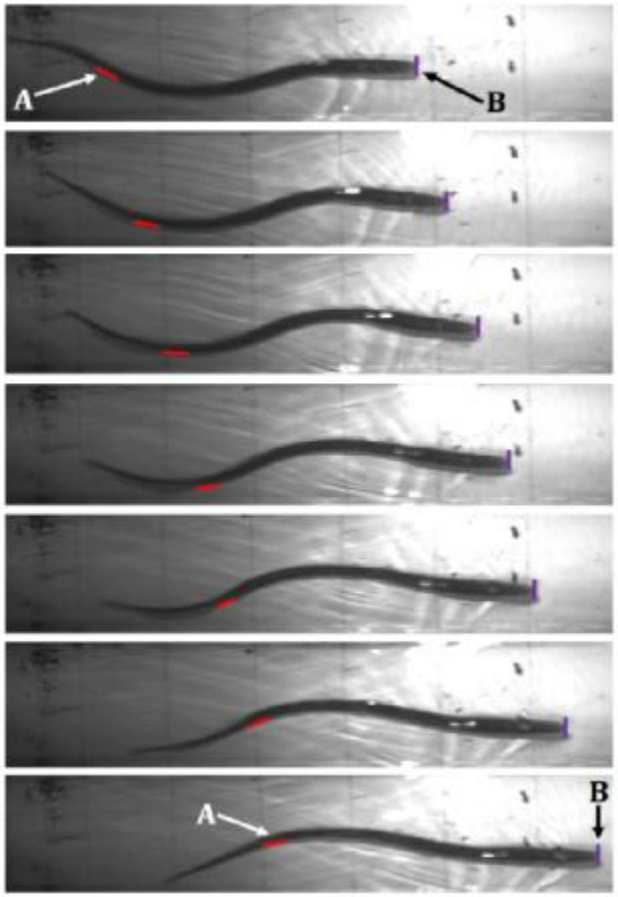

Sea Lamprey
(10-degrees)
0%
success
9%
success
75
60
45
30
15
0
Average Height (cm)
0.300
0.600
Discharge (L/sec)

Discharge


Sea Lamprey
(Overall)
24%
success
50%
success
75
60
45
30
15
0
Average Height (cm)
0.300
0.600
Discharge (L/sec)


Native Species
100%
success
95%
success
75
60
45
30
15
0
Average Height (cm)
0.300
0 .600
Discharge (L/sec)

The Story Continues



- Swimming at the air water interface may have implications for selective passage devices
  - *Fully submerged (7 cm)*
  - *Half submerged (3 cm)*
  - *Wetted Surface (1 cm)*
- Sea lamprey were tested in June-July 2016
  - *White suckers will be tested in June-July 2017*
- Early results for sea lamprey indicate a significant reduction in swimming efficiency at 1 cm

Conclusions

- Channel width did not significantly affect sea lamprey passage rates
- Ramp Angles ≥ 10-degrees block sea lamprey
- The effects of discharge are unclear for sea lamprey
  - ≥ 0.5 cm is likely required for native/desirable passage
- Moderate velocities and device length should facilitate high passage success for desirable species
  - Testing of a wider range of body morphologies and swimming abilities is required

Acknowledgements:
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